

BAM-1020

Ambient Particulate Mass Monitor

Keys to Obtaining High Quality Particulate Data

Using a PM_{2.5} Federal Equivalent Method

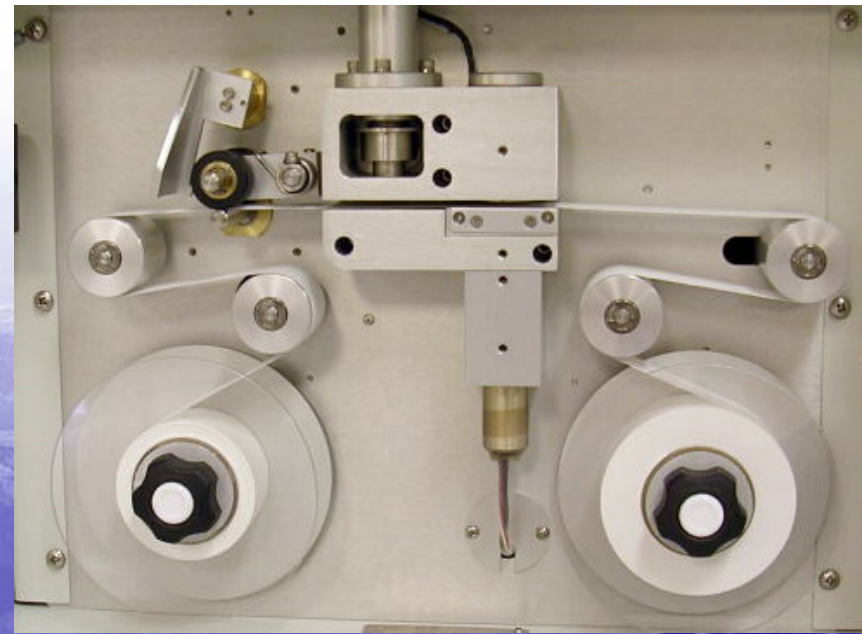
Dennis Hart - Met One Instruments, Inc.

Nov 2009 National Ambient Air Monitoring Conference

Overview

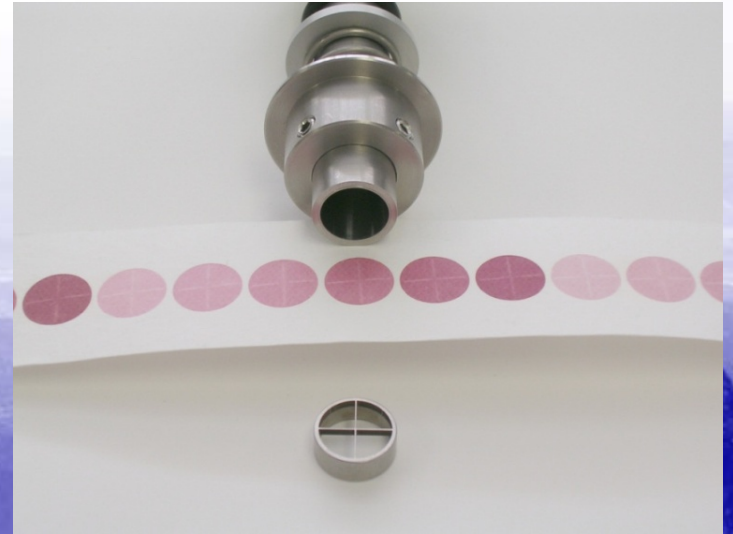
- Method Description and Functional Overview
- Typical FEM Configurations
- EPA PM_{2.5} FEM Test Protocol and Results
- Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”
- Critical Maintenance and Audits
- Recent Upgrades and Updates for the BAM-1020

Method Description



- At the beginning of the hour, a small Carbon 14 element emits beta rays through a clean spot of filter tape to determine a zero reading.
- The BAM advances this exact spot to the sample nozzle where air containing particulate is sampled onto the filter tape.
- At the end of the hour, the dirty spot is placed back at the source where it is re-measured with beta rays.
- The dusty spot attenuates the beta rays more than the clean spot did. The difference between the two measurements is related to the mass of the particulate by a variation of Beer's Law.

Method Description



- The BAM-1020 always makes a separate concentration measurement on a fresh spot of tape each hour.
- An automatic hourly membrane foil measurement verifies the span stability of the unit.
- The beta attenuation method is virtually unaffected by the chemical or elemental composition of the sampled particulate.
- A Smart Inlet Heater actively controls the RH of the sampled air.

Typical FEM Configurations

- The BAM-1020 is now designated as an EPA class III $PM_{2.5}$ PM_{10} and $PM_{10-2.5}$ Federal Equivalent Method (FEM), when equipped with the required settings and accessories.
- For $PM_{2.5}$ FEM monitoring, the unit must use the BGI VSCC-A $PM_{2.5}$ cyclone, along with the standard PM_{10} inlet, the BX-596 AT/BP sensor, and the BX-827 Smart Inlet Heater. The unit is operated with glass fiber filter tape, under actual conditions.
- For PM_{10} the cyclone is omitted and unit is operated with actual flow control, but standardized concentration reporting.

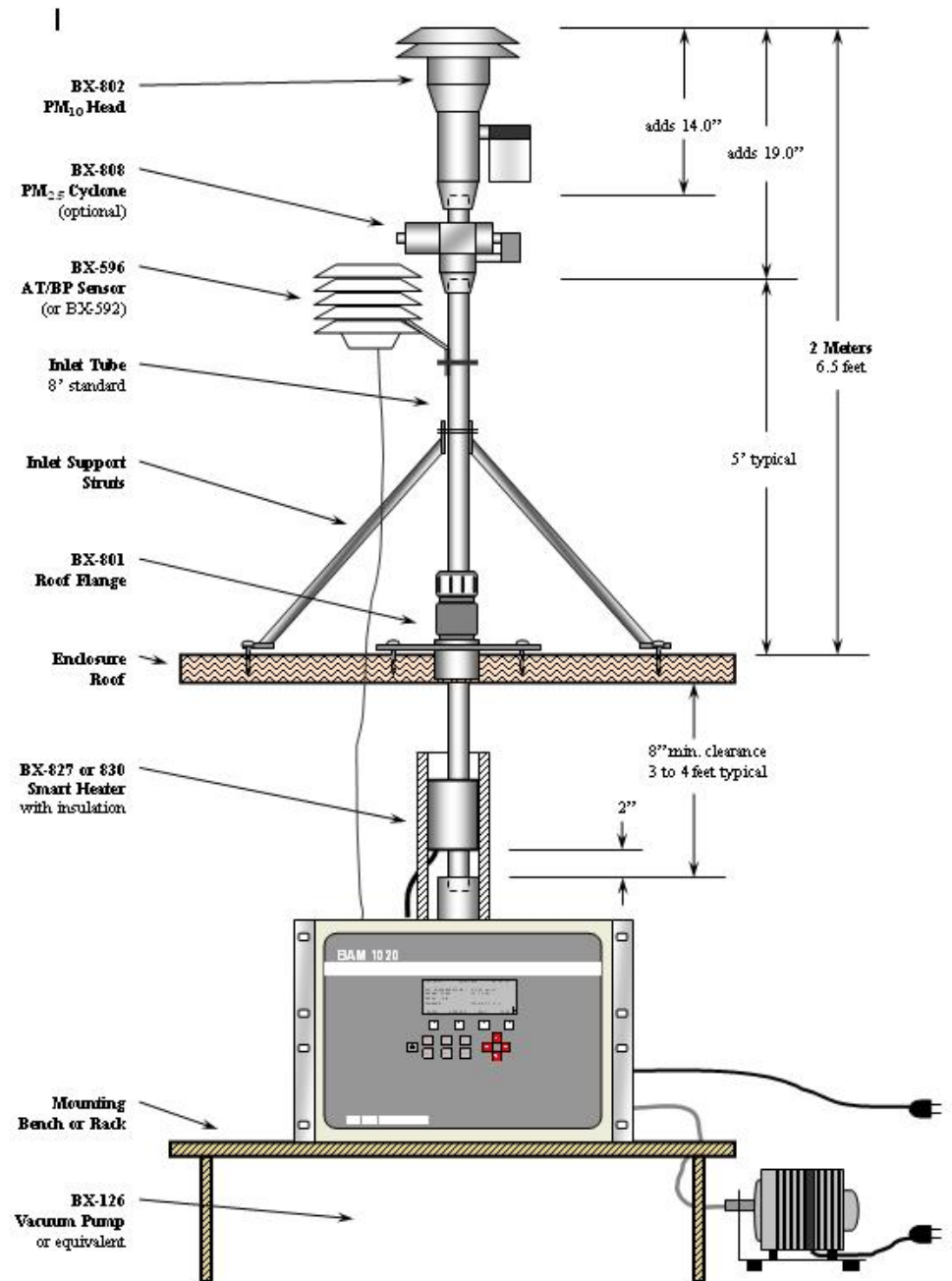


Typical FEM Configurations

The BAM-1020 is usually installed inside a walk-in shelter with a variety of other instruments.

This is the preferred installation type.

Bench-top or rack mountable.

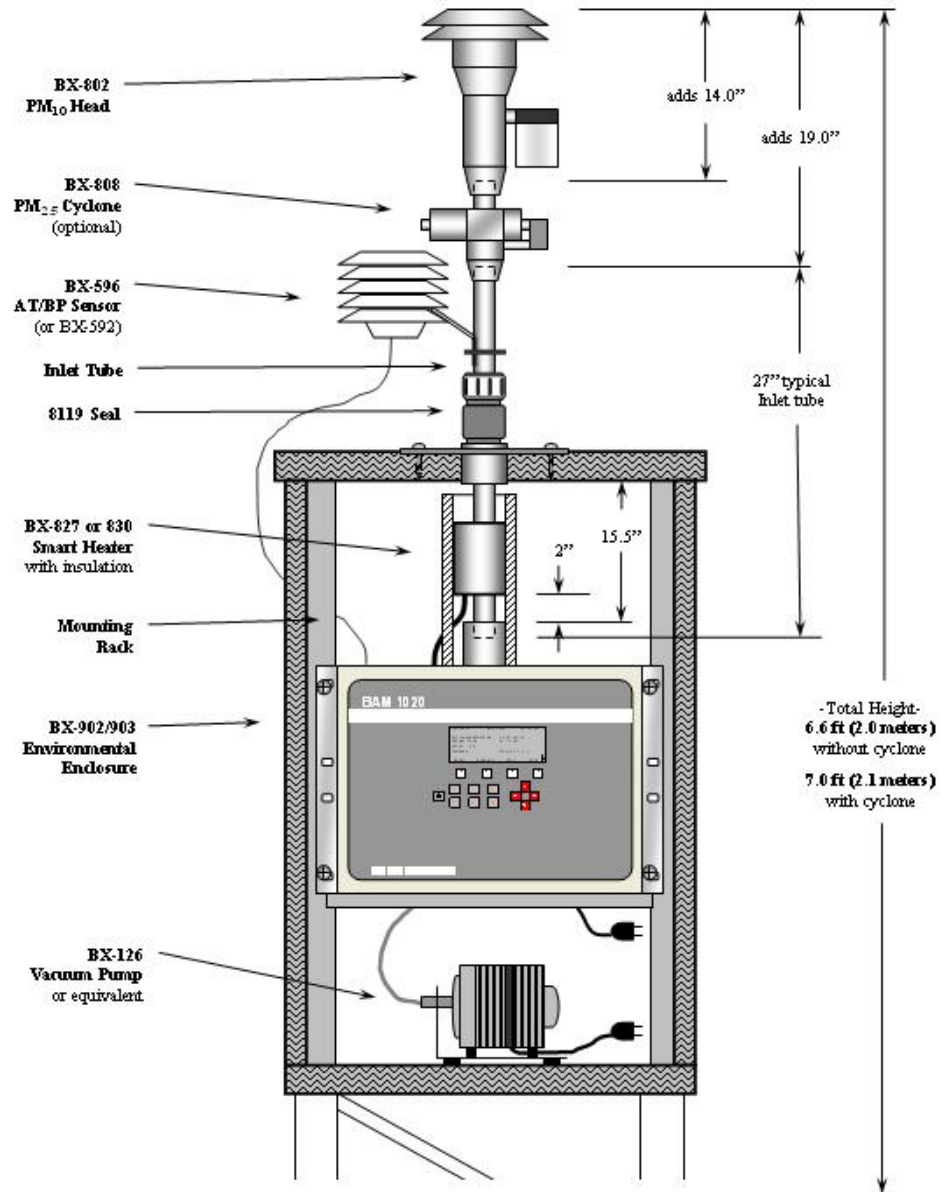


Typical FEM Configurations

BAM-1020s may also be installed inside mini weatherproof enclosures.

May be heated and/or air conditioned.

Often an economical solution, but less ideal for instrument stability.



EPA PM_{2.5} FEM Test Protocol

- Five test campaigns: Three winter, two summer.
- Winter: Logan UT, Allen Park MI, Bakersfield CA.
- Summer: New Haven CT, Bakersfield CA.
- Bakersfield was a summer and winter site.



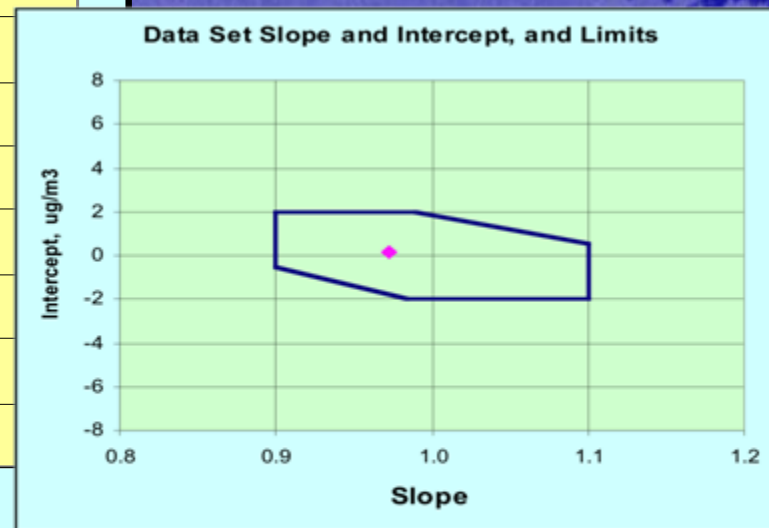
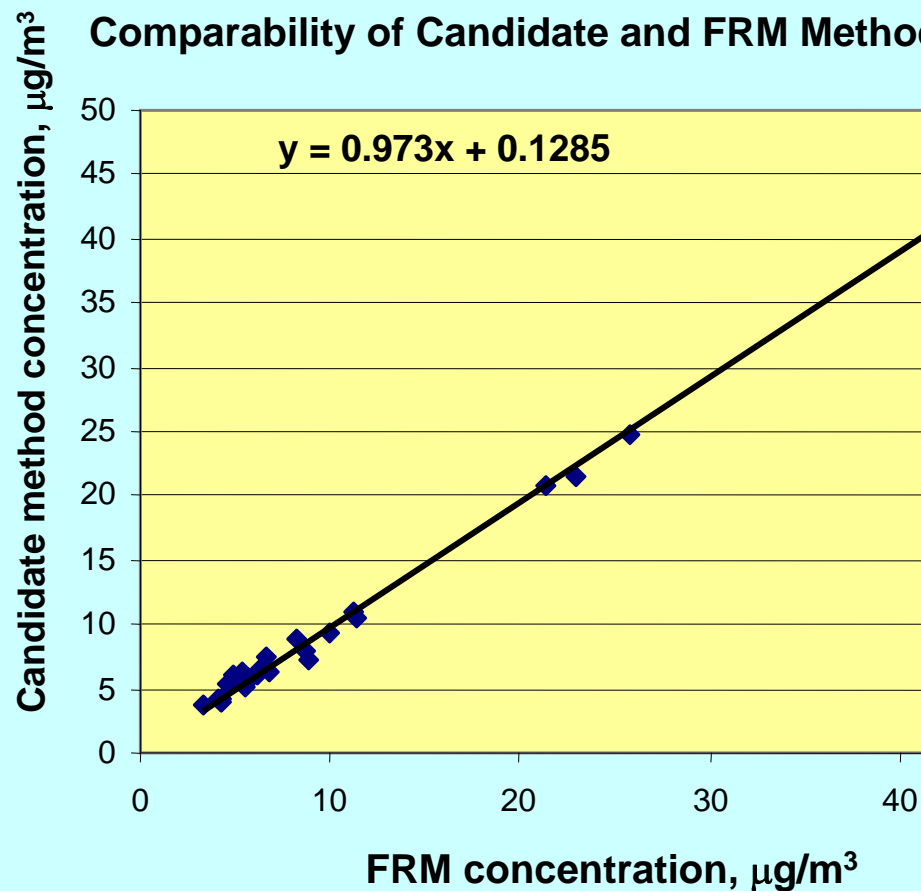
EPA PM_{2.5} FEM Test Protocol

- Triplicate BAM-1020 and FRM samplers at each site.
- Only single-channel FRM samplers allowed (BGI PQ-200).
- Minimum of 23 valid data days at each site. Minimum 46 valid days for the winter/summer site.
- 23-hour sample days (did not start at midnight). Service and filter retrieval occurred during one-hour downtime.
- Strict criteria for multiplicative (slope), additive (intercept) bias, and precision.
- All protocol pre-approved by the EPA.

Logan, Utah - Winter

Regression statistics		Slope ¹	Intercept ²	Correlation (r)
Statistics for this test site:		0.973	0.129	0.99751
Limits for PM2.5 Class III	Upper:	1.100	2.000	/ / / / /
	Lower:	0.900	-1.803	
Test Results (Pass/Fail):		PASS	PASS	PASS

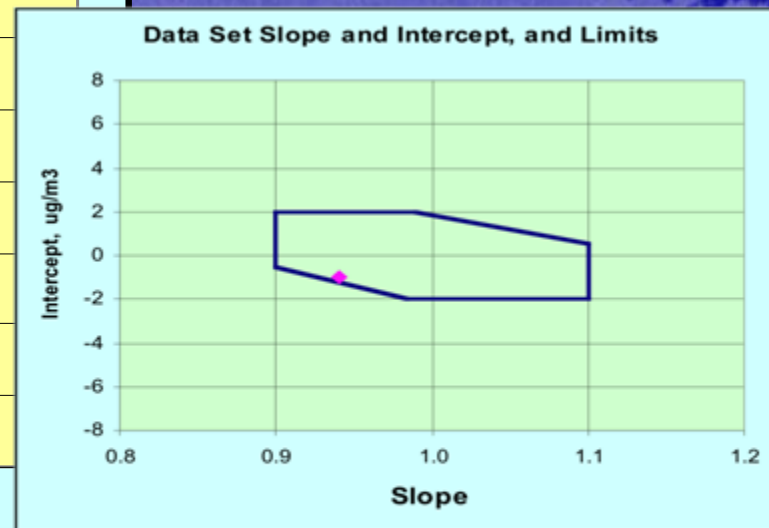
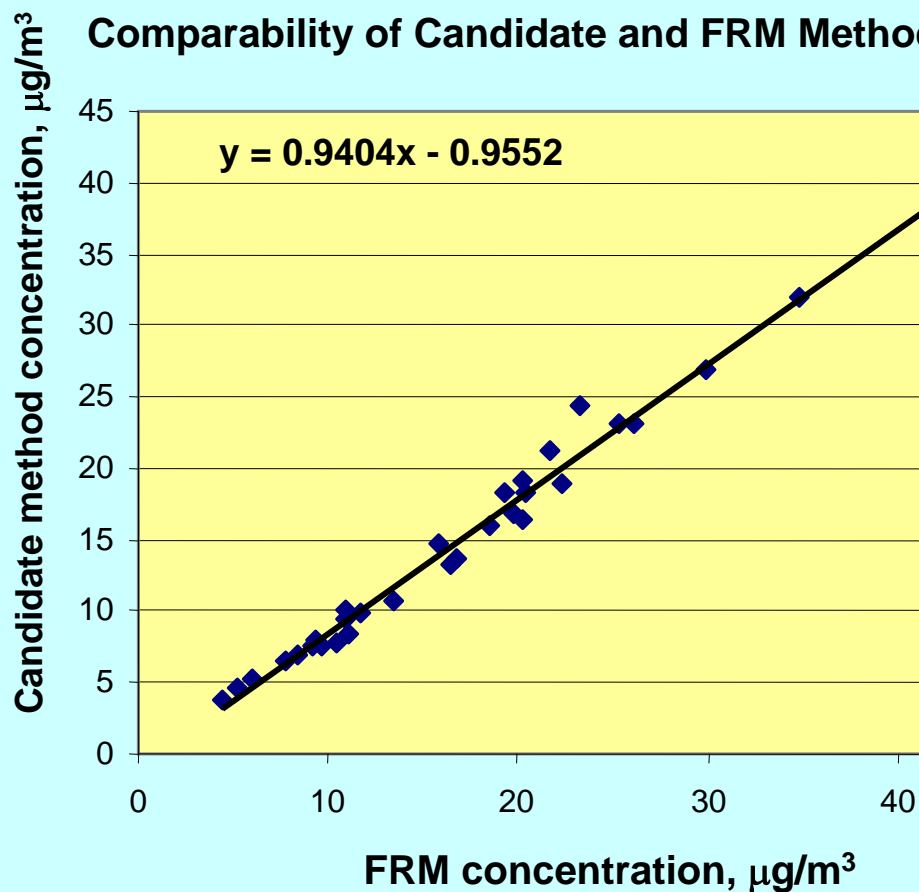
Comparability of Candidate and FRM Methods*



Allen Park, Michigan - Winter

Regression statistics		Slope ¹	Intercept ²	Correlation (r)
Statistics for this test site:		0.940	-0.955	0.99275
Limits for PM2.5 Class III	Upper:	1.100	2.000	/
	Lower:	0.900	-1.238	0.95000
Test Results (Pass/Fail):		PASS	PASS	PASS

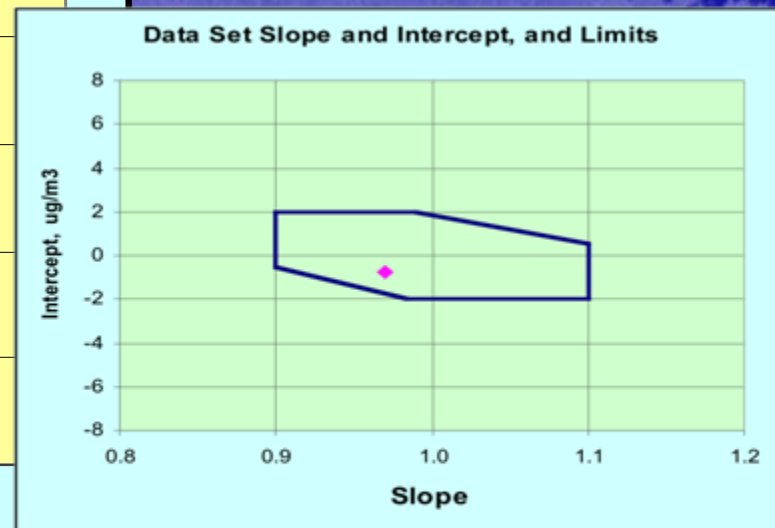
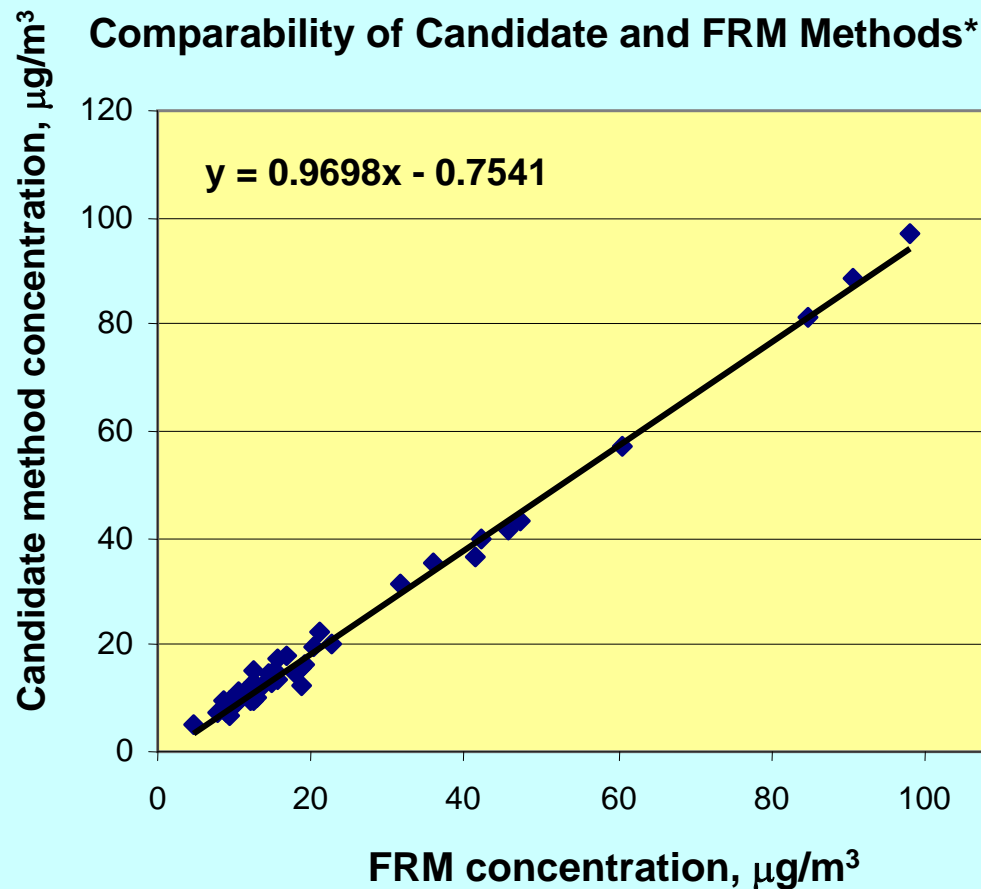
Comparability of Candidate and FRM Methods*



Bakersfield, California - Winter/Summer

Regression statistics		Slope ¹	Intercept ²	Correlation (r)
Statistics for this test site:		0.970	-0.754	0.99678
Limits for PM2.5 Class III	Upper:	1.100	2.000	0.95000
	Lower:	0.900	-1.748	
Test Results (Pass/Fail):		PASS	PASS	PASS

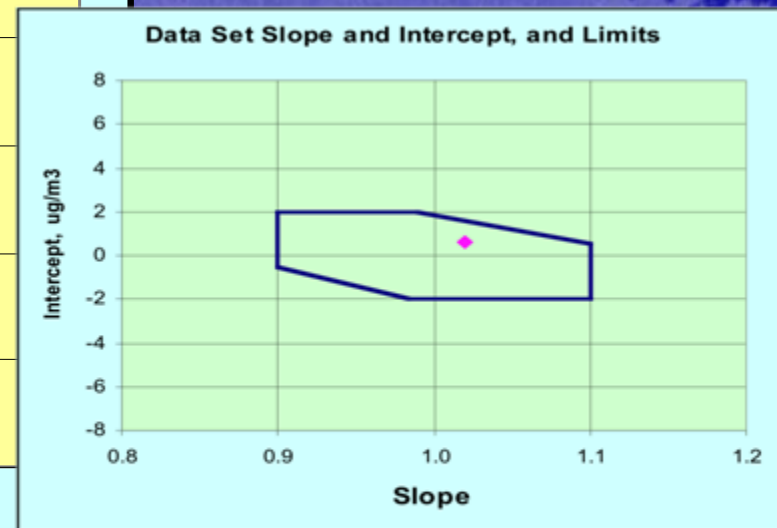
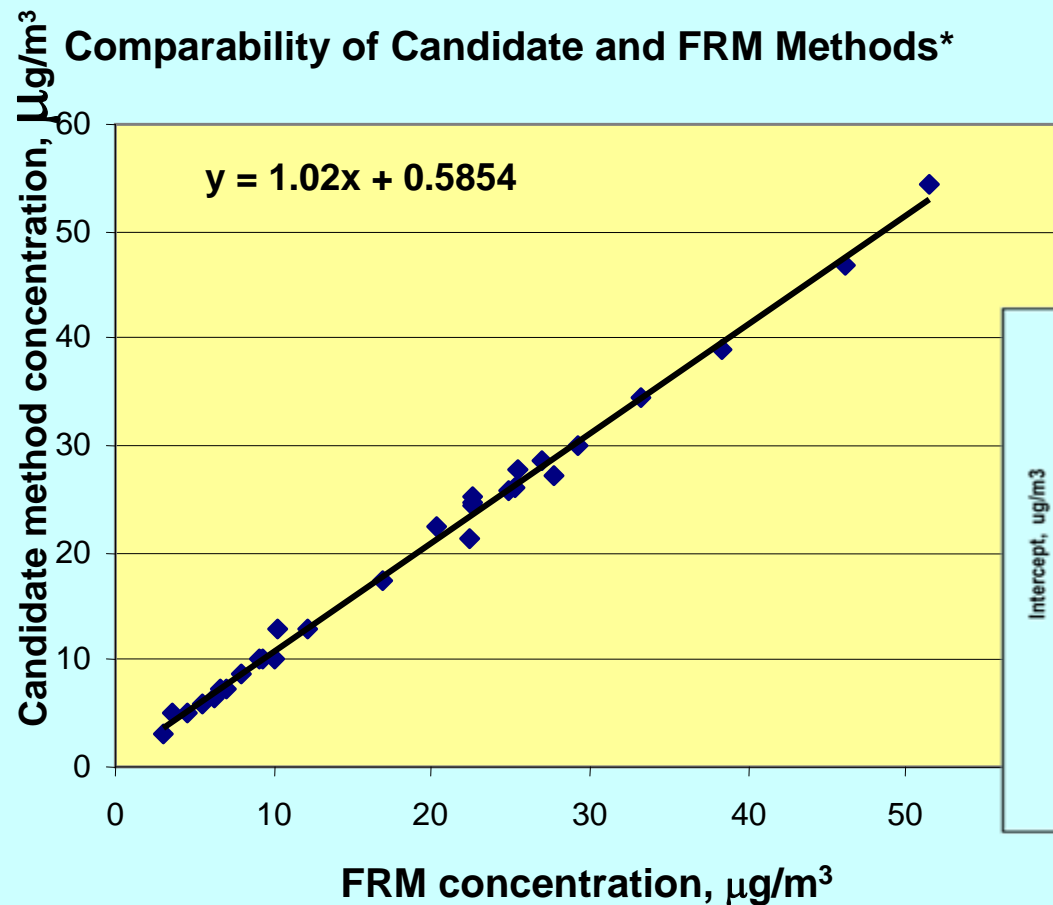
Comparability of Candidate and FRM Methods*



New Haven, Connecticut - Summer

Regression statistics		Slope ¹	Intercept ²	Correlation (r)
Statistics for this test site:		1.020	0.585	0.99765
Limits for PM2.5 Class III	Upper:	1.100	1.586	0.95000
	Lower:	0.900	-2.000	
Test Results (Pass/Fail):		PASS	PASS	PASS

Comparability of Candidate and FRM Methods*

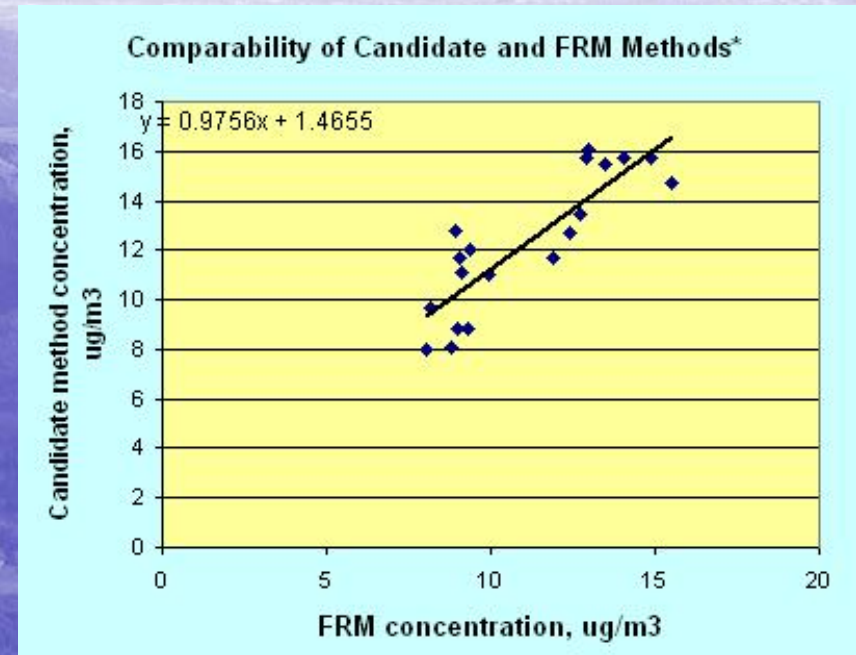


Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”

- Met One highly encourages FRM collocation while you are getting used to the BAM (or any other $\text{PM}_{2.5}$ FEM).
- Strict Collocation! Met One’s testing was performed with the samplers between 1 and 2 meters apart, and within 1 foot vertically. An FRM 100 feet away is not collocated.
- Very careful FRM filter handling.

Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”

- Look out for the statistical effects of a limited data set!
- It can be difficult to trend an accurate slope if the data points are all in a very narrow concentration range. Almost like sloping a single point.
- The solution is to continue to collect data until at least a couple of higher points are included.



Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”

- Moisture Control: Met One recommends always logging the filter RH on channel 4 of the BAM data array.
- Review the filter RH data and make sure the Smart Heater is doing its job. The BAM should do a good job of limiting the RH to near the required 35% setpoint.
- Be very careful if you calibrate the filter RH sensor! Incorrect calibration makes it appear that the RH is not regulating, and can cause excessive inlet heating.

Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”

- Analog output: Avoid using it for $\text{PM}_{2.5}$ unless necessary.
- There is often up to 1 ug of error in the digital-analog conversion.
- Correct data logger scaling is critical! 0-1 volts from the BAM does not usually equal 0 to 1000 ug, but instead -15 to 985 ug. Incorrect scaling looks like an offset.
- It is difficult to encode errors in the analog output.

Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”

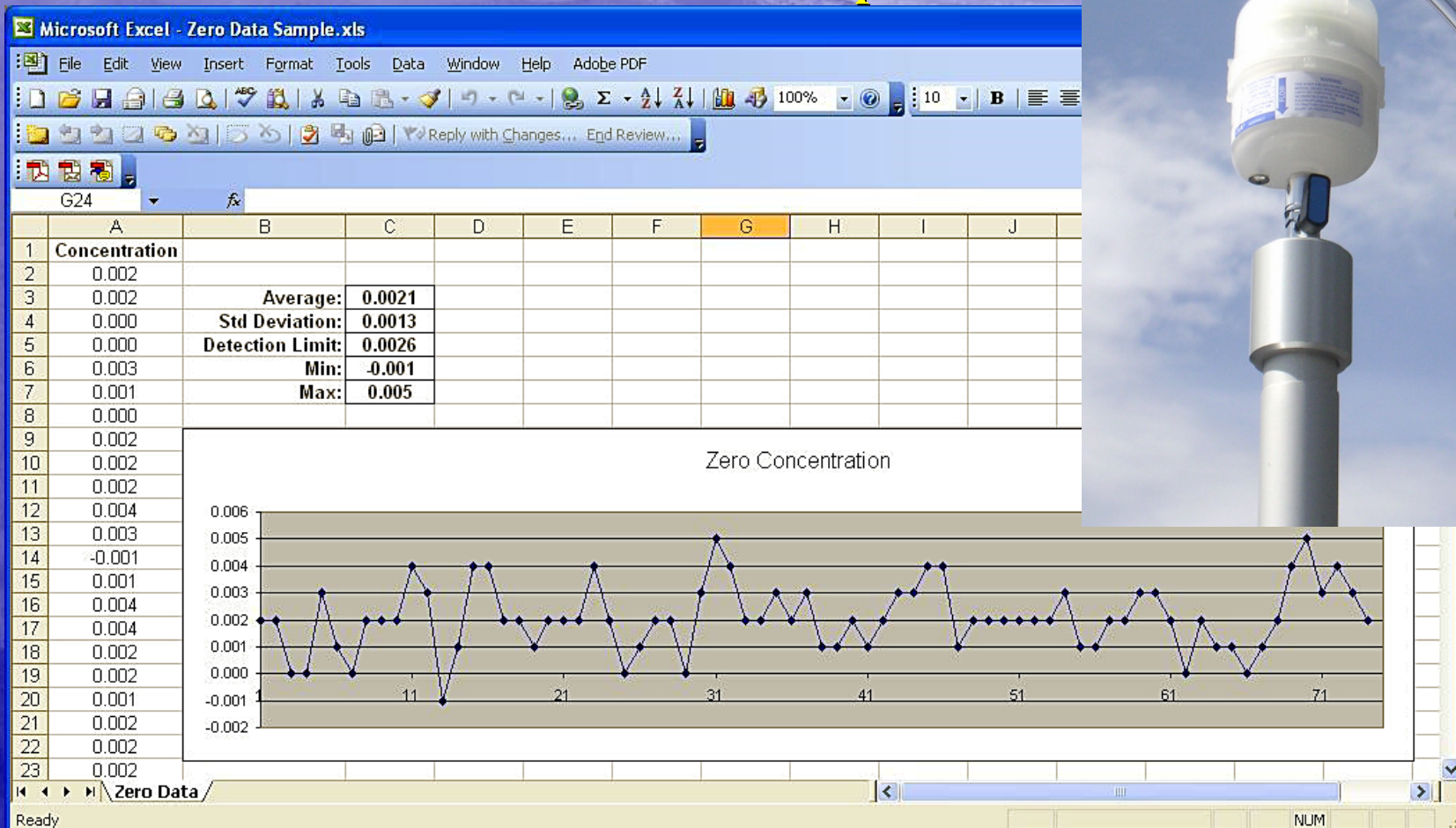
- Walk-in shelters provide the most stable environment for the BAM-1020. Use them whenever possible.
- Extra work is required if the mini shelters are used. Met One recommends logging the internal shelter temperature to make sure they do not over-heat or have sudden temperature changes.
- Sudden large temperature changes inside the shelter can appear as mass noise in the BAM-1020.
- Met One has some upgrades for the BX-902 mini shelters.

Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”

- The zero filter test is required at $PM_{2.5}$ FEM BAM-1020 field deployment and recommended as an annual audit.
- The BAM is run under field conditions, except the zero filter prevents any particles from collecting on the tape.
- The goal is to fine-tune the background so that the noise band is perfectly centered around 0 ug. This was not needed for PM_{10} .
- Always set the existing BKGD value to zero during the test.
- Any source of noise that will affect the BAM will also appear in the zero filter test!
- The BAM-1020 1-hour and 24-hour noise band and detection limits are clearly defined and auditable with this method.

Tips and Tricks: “How Do I Obtain FEM-Quality Results With My BAM-1020?”

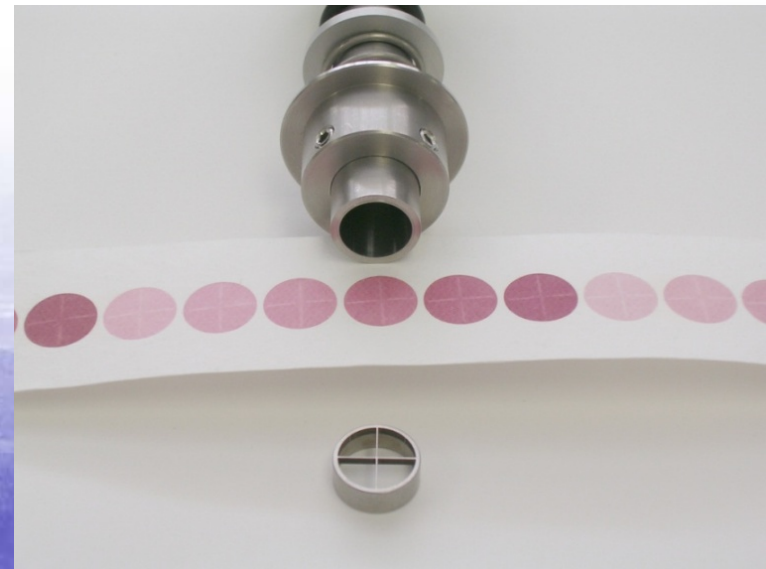
Zero Test Sample



Critical Maintenance

- The BAM-1020 filter tape roll will last just over 60 days, so this is the absolute minimum service interval.
- The cyclone and PM_{10} head particle traps should be cleaned on a monthly basis.
- The leak checks, nozzle/vane cleaning, and flow audits are the three critical BAM-1020 maintenance items, and are usually performed on the same monthly basis.
- Complete maintenance and audits can usually be performed in less than 15 minutes.

Critical Maintenance



- A leak check is always performed during flow audits as a data validation check, since a flow leak is basically the only problem that the BAM-1020 may not automatically detect.
- Unresolved leaks may cause positive or negative concentration errors.
- The sample nozzle and tape support vane must be kept clean to prevent nozzle leaks. Tends to be more necessary in humid areas.
- Flow audits consist of simple ambient temperature, barometric pressure, and air flow checks using the same traceable reference devices that would be used for your FRM sampler. Met One recommends BGI deltaCal.

Recent Updates for the BAM-1020

- BX-965 Report Processor is a new option that allows digital data collection at any time without delay. It also contains extra memory and USB converters, and network connection for the PM-Coarse paired configuration.
- Per user requests, Met One is working on expanding the BAM-1020 digital data output for increased flexibility and simplicity when used with digital data collection systems. This will be available as a free firmware update in the near future.
- Met One is phasing out the upgrade program for older BAM-1020 units in favor of the generous trade-in program.

Recent Updates for the BAM-1020

- The BAM-1020 coarse solution is designed for maximum flexibility.
- The $PM_{2.5}$ $PM_{10-2.5}$ and PM_{10} (standard and actual) values are all available from a single data array.
- The two units may be separated for stand-alone FEM use at any time.

